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Factors and measures of business process modelling: model building through a multiple case study

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Abstract
Business process modelling has gained widespread acceptance as a valuable design and management technique for a variety of purposes. While there has been much research on process modelling techniques and corresponding tools, there has been little empirical research into the success factors of effective process modelling, and the *post hoc* evaluation of process modelling success. This paper reports on the first attempt to identify process modelling success factors and measures, as empirically evidenced in case studies of nine process modelling projects in three leading Australian organizations.

Keywords: business process modelling; success factors; success measures; case study method

Introduction

Process modelling is an approach for visually depicting how businesses conduct their operations: defining and depicting entities, activities, enablers and the relationships between them (Curtis *et al*., 1992; Gill, 1999, p 5). It is widely used within organizations as a method to increase awareness and knowledge of business processes, and to deconstruct organizational complexity (Davenport, 1993; Hammer & Champy, 1993; Smith & Fingar, 2003). In this study, the term 'Business Process Modelling' encompasses all graphical representations of business processes, and related elements such as data, resources, etc., as employed for diverse purposes including process documentation, process improvement, compliance, software implementation or quality certification, among others.

Flowcharting and process mapping have been around since F.W. Taylor and the dawn of Taylorism. Today more commonly referred to as process '*modelling*', this approach is claimed to be more disciplined, standardized, consistent, mature and scientific (i.e., Scheer, 2000), and increasingly focused on the modelling of *business* processes. Business process modelling initiatives have grown in size and complexity, with some organizations conducting process modelling enterprise-wide, even globally (i.e., Gulla & Brasethvikt, 2000; Forsberg *et al*., 2000; Scheer *et al*., 2003; Becker *et al*., 2005). Concomitantly, the related investment in process modelling tools, methodologies, training and the modelling activity has for these organizations become large enough to attract scrutiny.

The success or not of process modelling has become a critical concern, as its consequences can often be substantial, resulting in the implementation of new processes, organizational structures and subsequently IT systems. Yet, little research attention has been directed at process modelling best practices, or on the *post hoc* evaluation of process modelling projects. This study addresses this knowledge gap, with two main research questions:

- How can the success of a process modelling initiative be measured?
- What are the important success factors of process modelling?

To our knowledge, this is the *first* published study that attempts to empirically measure the success of process modelling initiatives. The study unit-of-analysis is the 'process modelling project'. In the context of this study, the process modelling project is considered a success if it is *effective and efficient.* A process modelling project can be considered *effective* to the extent it fulfills its objectives. A process modelling project can be considered *efficient* to the extent that process modelling activities are com- pleted within the allocated time and budget. The study aims to evaluate multiple independent variables (here- after referred to as success factors) and multiple depen- dent variables (hereafter referred to as success measures) pertaining to the success of process modelling projects.

This paper reports on the first attempt to identify process modelling success factors and measures, as empirically evidenced in case studies of nine process modelling projects in three large Australian organiza- tions. The remainder of the paper will first present a brief literature review followed by the multiple case study design employed. Next, the case studies are briefly introduced, followed by discussion of the findings. The paper concludes by summarizing the study contributions, limitations and recommended follow-up.

Literature review

Past studies have described and justified the use of process modelling at various stages of systems imple- mentations. Process modelling is used for (1) model- based identification of process weaknesses, (2) adapting best business practices, (3) the design of a new business blueprint (as a form of documentation and communica- tion), and (4) end-user training (Curtis *et al*., 1992; Becker, Rosemann & Schütte, 1997; Bartholomew, 1999; Gulla & Brasethvik, 2000; Peristeras & Tarabanis, 2000; Rosemann, 2000). The literature also reports how process modelling has been employed in a range of different applications, including: activity based costing, supply chain management, customer relationship management, total quality management, workflow management, knowledge management and simulation (Curtis *et al*., 1992; Becker *et al*., 2000, Rosemann, 2000). Information systems (IS) success factor studies, especially those reporting on large-scale multimillion dollar implementa- tions such as Enterprise Systems projects, explicitly and implicitly suggest the importance of process modelling and its contribution to the success of these projects (Clemons *et al*., 1995; Bancroft, 1998; Wreden, 1998; Parr *et al*., 1999; Forsberg *et al*., 2000). Kesari *et al*. (2003) specifically state the advantages of process modelling in IS projects and classify process modelling benefits into three main categories. These include Documentation benefits (a common language with clients, a means for basic communication and having a flexible template); Design benefits (understanding the current business processes, generation of new possibilities and a means of planning for the project implementation), and Use benefits (visual representation of processes, supporting the iterative development process of systems and time efficiency).

Most of the published work pertaining to process modelling describes how to use certain modelling tools (e.g., Scheer, 1998a) or describes the application of modelling languages (e.g., Rosemann & zur Mühlen, 1997). Some articles provide descriptions in the form of case narratives based on reflective learning from past projects (e.g., Scheer *et al*., 2002). New streams of process modelling research, such as the use of reference process models, are now emerging (e.g., Rosemann & Chan, 2000; Fettke & Loos, 2003). One framework deemed relevant and useful for the process modelling context is the Guidelines of Modelling framework (Becker *et al*., 2000). It presents six dimensions of quality that can be used to evaluate a process model. However, no empirical testing of the framework has been reported to date. Overall, empirical studies on process modelling are scarce and, to the authors' best knowledge, there have been no studies that identify and describe essential elements that should exist in a process modelling project or how to evaluate the overall success of a process modelling project. Addressing this gap has been the motivation for this study.

Research design

An *a priori* process modelling success model was derived from the literature, and a multiple case study design chosen to further validate the *a priori* model.

Deriving the *a priori* model

Success factors within the context of this research can be defined as those key elements that will ensure the process modelling project to proceed effectively and complete successfully (following Mcnurlin & Sprague, 1989, p. 97). Owing to the lack of theoretical and empirical evidence of process modelling success factors, a review of related literature sought to identify analogous factors of success. Domains explored included (1) business process model- ling; (2) software engineering and conceptual modelling success; (3) information model quality features; (4) business process reengineering and Enterprise Systems success; and (5) IS success. Sedera *et al*. (2001) report in detail on the identification and justification of the selected analogous domains, and the rational for success factor adoption. Table 1 summarizes their results.

Preliminary analysis of factors identified from the literature suggested 11 candidate success factors. These factors were broadly grouped within two categories:

Table 1 Cross-reference literature review of candidate process modelling success factors (from Sedera *et al.*, 2001)

Study	*Area/domain*	*Model-specific factors*			*Context-specific factors*							
		Methodology	*Tool*	*Language*	*Modeller's expertise*	*Team orientation*	*Project management*	*User participation*	*Top management support*	*User training*	*Project championship*	*Communication*
Bingi *et al*. (1999)	ES				X*	X*	X*		X	X		
Sumner (1998)	ES					X*			X	X		
Holland *et al*. (1999)	ES	X*				X	X	X	X			X
Stefanou (1999)	ES					X			X	X*	X	X
Raymond *et al*. (1995)	BPR	X*							X*			
Grover *et al*. (1995)	BPR		X*				X			X*		
Clemons (1995)	BPR	X*	X*				X*	X*	X*			
Evans (1994)	BPR							X*				X
Larsen & Myers (1998)	BPR					X			X			X
Murphy & Staples (1998)	BPR	X*	X*				X		X			X
Davenport (1993)	BPR		X									
Kettinger & Teng (1997)	BPR		X									
Carr & Johanson (1995)	BPR		X									
Hammer & Champy (1993)	BPR	X				X	X					X
Amoroso (1998)	BPR											
Smyth (1999)	CASE		X*									
Burkhard (1990)	CASE	X					X	X	X	X		X
McClure (1979)	Software engineering		X		X	X			X			
Brash (1999)	Enterprise modelling							X				
Rosemann (1998)	Process modelling–quality		X*	X*			X*	X*				X
Moody & Shanks (1997)	Data modelling – quality						X*	X				X
Moody (1996)	Data modelling				X			X				X
Lindland *et al*. (1994)	Conceptual modelling – quality		X	X				X	X*			X
Green & Rosemann (2000)	Process modelling–ontological evaluation			X								
Batini *et al*. (1985)	Conceptual modelling – (diagramming)			X*								
Krogstie *et al* (1995a, b)	Requirements engineering – quality											
Delone & Mc Lean (1992)	IS							X				
Bailey & Pearson (1983)	IS							X				
Ginzberg (1981)	IS							X				
Ives & Olson (1984)	IS							X				
Lucas (1981)	IS							X				
Lucas *et al.* (1998)	IS							X				
Raymond (1995)	IS							X				
Fisher (2000)	IS							X				
Davis (1989)	IS							X				
Warne & Hart (1996)	IS								X*			
Inchusta *et al*. (1998)	IS		X*						X	X	X	
Srivihok (1999)	IS – EIS							X		X*		X
Rainer & Watson (1995)	IS – EIS							X				X
Chuang & Shaw (2000)	ES and IS				X	X*	X*		X			

'X' ¼ studies where the identified factors were identified as being particularly important for success.
'X*' ¼ studies that implied the existence of the factors would benefit the initiative (complete references to the studies presented in this table can be obtained in Sedera *et al*., 2001).

'modelling-related factors' (factors that were specific to process modelling) and 'project-specific factors' (factors that are common to most IS projects). Both these categories were investigated, with the aim of obtaining a holistic view on those factors that are most influential on the level of process modelling success experienced. Table 2 includes brief definitions of the 11 *a priori* process modelling success factors identified through this process.

Success is a complex, multi-dimensional phenomenon. Hence, having a correct and complete set of measurement dimensions is important (Garrity & Sanders, 1998, p 31; Kanellis *et al*., 1999). Gable (1996) suggests that the employment of only one or a subset of the dimensions of success as a surrogate for overall success may be one of the reasons for mixed results reported in the literature regarding the antecedents of IS success (e.g., Ginzberg, 1981; Ives & Olson, 1984; Barki & Hartwick, 1989; Hawk& Aldag, 1990; Gatian, 1994, Myers *et al*., 1998).

Owing to the lack of any reported process modelling success studies, IS success frameworks were sought as a proxy to identify candidate process modelling success measures (e.g., De Lone & Mclean, 1992; Goodhue, 1992; Seddon, 1997; Garrity & Sanders, 1998; Myers *et al*., 1998). Sedera *et al*. (2002) describe and justify the identification, re-specification and adaptation of these success frameworks and extracted measures, relating them to the process modelling context. Five *a priori* process modelling success measures were identified through this process (see Table 3).

Table 2 Defining the *a priori* constructs – independent variables: success factors

***Modelling methodology*:** A detailed set of instructions that describes and guides the process of modelling.

Modelling language: The grammar or the ''syntactic rules'' of the selected process modelling technique.

Modelling tool: The software that facilitates the design, maintenance and distribution of process models.

Modellers' expertise: The experiences of the process modellers in terms of conceptual modelling in general and process modelling in particular.

Modelling team structure: The 'infrastructure' that should exist in a successful process modelling team, such as an appropriate mix of internal and external members, representatives from all modelled business units, team leadership and vision.

Project management: The management of the process modelling project including defining the project scope, aims, milestones and plans.

User participation: The degree of input from the process model users to the design, approval and maintenance of the process models. *User* ***competence***: The amount of knowledge the model users have about the modelled domain and the modelling procedures.

Top management support: The level of commitment by senior management in the organization to the process modelling project, in terms of their own involvement and the willingness to allocate valuable organizational resources.

***Leadership** (a.k.a. project championship)*: The existence of a high level sponsor who has the power to steer the project, by setting goals and legitimate changes.

Communication: The exchange of information (feedback and re- views) amongst the project team members and the analysis of feedback from users.

The process modelling success measures were mainly based on the De Lone & Mclean (1992) model together with its subsequent revised versions and adaptations. The 'Modeller Satisfaction' construct is unique to the pro- posed model. This was included in the model to tap into the affective attitude of the modeller (analogous to the developer of a system rather than a user) (Sedera *et al*., 2002, p 335). The system quality and information quality dimensions of the original IS success frameworks were replaced by the new dimension 'process-model quality' (Sedera *et al*., 2002, p 336). 'Use' has been identified as one of the most frequently reported measures of success of an IS (De Lone & Mclean, 1992, p 66). This framework also proposes 'model use' to be an important dimension of process modelling success (Sedera *et al*., 2002, p 336). 'User satisfaction' has been employed as a core dimension of IS success in many past studies (Sedera *et al*., 2002, pp 336–337) and hence was adopted herein as well. Most of the success frameworks reviewed included an 'impact' section to capture either the individual, workgroup, organizational or social impacts of the IS. In the context of this study, we have used 'process impact' *in lieu* of the other impacts proposed in analogous literature (Sedera *et al*., 2002, p 337).

Figure 1 depicts the resultant *a priori* model. The *a priori* model derived from the literature ostensibly reflects a complete set of success factors and success measures.

The use of case studies

The case study method emphasizes qualitative analysis.. It is a scientific and recommended way to research an emerging area in which few previous studies have been conducted (Lee, 1989; Yin, 1994). A single pilot-case study and subsequent multiple case studies were employed in this research, the primary goal being to instantiate the candidate success factors and measures identified from the literature review.

Table 3 Defining the *a priori* constructs – the dependent variables: success measures

Modeller satisfaction: The extent to which the modellers (those who design the process models) believe process modelling fulfills the objectives that underlay the modelling project.
Process model quality: The extent to which all desirable properties of a model are fulfilled to satisfy the needs of the model users in an effective and efficient way.
Model use: The extent to which the process models are applied and utilized.
User satisfaction: The extent to which the model users believe process modelling fulfills the objectives that underlay the modelling project.
Process impact: The effects of process modelling on the process' performance. Here, the 'process' refers to the processes or functions to which process modelling is being applied.

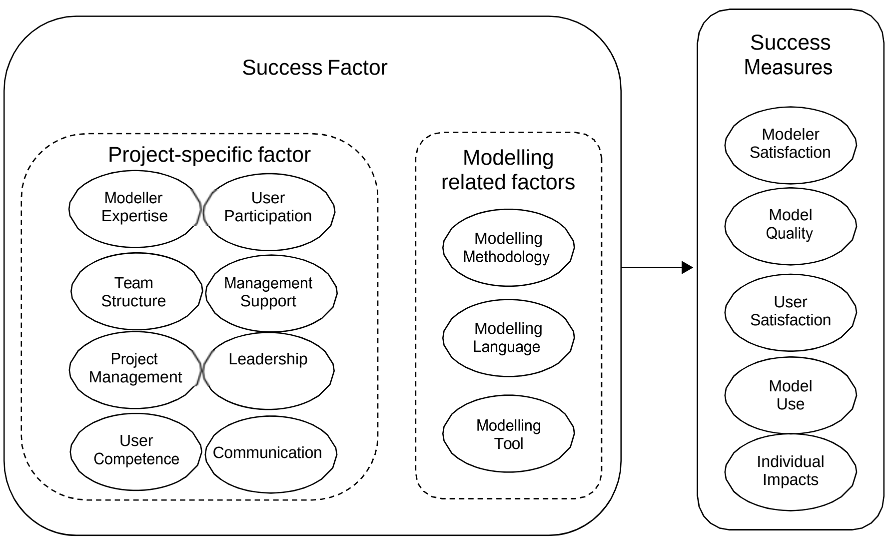

Figure 1 *A priori* model.

Case study design

In attention to several known potential weaknesses of the case study method (Benbasat *et al*., 1987), a case study protocol was designed, carefully documenting all procedures relating to the data collection and analysis phases of the study.

Qualitative data collection mechanisms including in- depth interviews, and content analysis of existing documentation were used to collect 'rich' evidence about the process modelling projects. Observations and documentation were used only to augment and corroborate interview data, which was the main input to data analysis. Whenever possible, interviews were conducted with multiple stakeholders in the process modelling project(s), namely the modellers and the project sponsors. The interviews were semi-structured, each completed within 60–90 min. All interviews followed the same structure and format (as prespecified by the case protocol), commencing with an open discussion on perceived success/failure factors and measures of process modelling success in relation to the selected project. Subsequently, the individual constructs of the *a priori* model were introduced (for the first time), and the respondents' opinions on the overall relevance and importance of these constructs were sought. This approach enabled the researchers to obtain new ideas to enhance the model, while simultaneously validating existing *a priori constructs*.

Reliability was enhanced through the use of a detailed case protocol and a structured case database. All relevant data (interview transcripts, research memos, sample process models, documented modelling guidelines, etc.) were maintained in a 'case database' (Yin, 1994; Miles &

Huberman, 1994) and close linkages between the research questions, evidence, interpretations and conclusions were maintained throughout the analysis. The qualitative data analysis tool NVivo 2.0 was utilized during this phase to capture, code and report the findings of the case study. Construct validity was strengthened within the study through the use of multiple sources of evidence, establishing a chain of evidence with a well- structured case database, and by having key informants review draft case study reports at the completion of data analysis at each case site. Predictive validity was increased through data analysis techniques such as pattern matching and explanation building (Yin, 1994). External validity, or extensibility of the findings, has been improved through the conduct of multiple cases studies.

Introducing the case studies

Case studies were conducted of four, one and four (nine in total) process modelling projects (the process model- ling project is the unit of analysis) in three large Australian organizations – Queensland Rail (QR), Queens- land Treasury and Telstra, respectively.

QR is a Queensland State Government owned corporation that provides transport and logistics business solutions to a diverse range of customers throughout the State, Australia and overseas. Business process modelling is used within QR for a variety of purposes. Over a period of 4 months (July–November 2002), 18 interviews/meetings were conducted with modelers and project sponsors involved in four process modelling projects within QR. Over 30 project-related documents (e.g., project charters, business cases, modelling-related procedures, project management documentation, etc.) were analyzed in detail.

Queensland Treasury provides core economic and financial policy advice to the Queensland Government, and assists the government in managing the State's finances, including the preparation and oversight of the budget to meet community needs. Over a 4-week period (April–May 2003), four detailed interviews and over 10 different types of documents were assessed in relation to a single detailed process modelling project at Queensland Treasury.

Telstra is a semi-government telecommunications organization with a 100-year history of providing telecommunications services to the whole of Australia. Telstra competes in a very competitive global market, and is continuously revising its strategies and business processes. Small- and large-scale projects have been initiated within Telstra for the continuous improvement of its products and services. Process modelling has played a substantial role in many of these corporate initiatives. Four process modelling projects were analyzed over a period of 2 months (June–August 2003). Six key respondents were interviewed at 11 meetings, and a range of project-related documents were analyzed in detail.

Multiple case study findings

Explicit or implicit counts are often reflected in qualitative analysis when judgments are made. For example, we 'identify themes or patterns that happened a number of times and that consistently happen a specific way' (Miles & Huberman, 1984, p 215). Analysis of the case study data was conducted mainly by coding the data (through the use of NVivo 2.0), thereby yielding counts and data points that were then analyzed further.

A starting set of codes was defined ('Codes are tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study'; Miles & Huberman, 1984, p 55, 57); these codes were refined, as the analysis evolved. A tree-like node structure was initially created within NVivo to depict the success factors and success measures of the *a priori* model. The coding of the interview data was then conducted in three phases:

Phase 1: Phase 1 coded any direct or implied existence of the constructs (of the *a priori* model) within the data, simultaneously identifying any new constructs.

Phase 2: Phase 2 analysed the information already coded within phase 1 (extracting the information already coded under each of the constructs), to confirm the appropriateness with the categorization. Furthermore, the codes assigned to the data were refined to distinguish between citations that indicated mere existence of the constructs, *vs* those that specified the criticality of the construct.

Phase 3: Phase 3 conducted *in vivo* coding, that is, a method of coding available through NVivo, in which the selected document text becomes the title of a new node, created to hold that text. Key words are identified and allocated to each construct as a means of identifying potential sub-constructs.

Table 4 indicates general citations (each time the construct was merely mentioned) by interviewee (internal or external modeller, or project sponsor) within each of the nine modelling projects. The primary goal of this analysis was: (a) to evaluate the sufficiency of the set of model constructs, and (b) to evaluate the necessity of each model construct. Table 4 reflects 16 success factors (F1–F16) and nine success measures (S1–S9). F1–F11 are the starting 11 success factors of the *a priori* model, while F12–F16 are new independent variables identified through the case studies. S1–S5 are the starting five success measures of the *a priori* model, while S6–S9 are new success measures identified through the case studies. In addition to analysing the general citations for each construct, we also (a) conducted redundancy checks with 'matrix intersection and difference' searches using NVivo, and (b) analysed each construct against its general citations and those instances in which it was specifically stated as being important for a successful process modelling initiative (hereafter referred to as specific citations). Matrix intersection search is a type of Boolean search made available through NVivo. It takes one feature from each collection at a time, and finds passages in the documents or nodes, which contain both. Matrix difference search, another type of NVivo Boolean search, takes one feature from each collection at a time, and finds

passages in the documents or nodes having the feature from the first collection but not the second. Complete evidence of this data analysis results (such as sample citations and resulting matrices) was not included in this paper due to space constraints, but can be provided upon
request.

Redundancy checks enabled the researcher to identify possible instances where two or more constructs over- lapped each other, and when potential sub-constructs were incorrectly depicted as core constructs in the *a priori* model. The tool's (NVivo 2.0) capacity to maintain a chain of evidence, with its provision to move back and forth from the summary matrices to the original transcripts and memo notes in the case database, aided the researchers to carefully analyse and justify modifications to the model, raised through these redundancy checks.

Comparison of citations that merely mentioned a construct with instances that specifically stated its importance was used to justify the criticality or necessity of each construct. These 'specific' citations were analyzed in conjunction with the general citations and redundancy matrixes as further evidence when deciding the inclusion/exclusion and merging of *a priori* constructs for the re-specified model. The following section describes the process of deriving the re-specified model.

Respecifying the independent variables: the success factors

Top Management Support (F1) was consistently cited across interviewees (modellers and project sponsors), across projects and across case sites.. However, overlap was perceived across the case sites with other *a priori* constructs such as Leadership. Close analysis of the interview data suggested that aspects of management support, such as funding and management participation, played a substantial role in successful modelling projects. Thus, Top Management Support was kept as a separate construct, and the overlap with other constructs was noted, to guide subsequent model operationalization. The respondents consistently cited *Leadership (F2)*, ar- guing its relevance and importance as a success factor of process modelling projects. However, as suggested, there was substantial overlap with the data coded under Top Management Support (this became evident after a matrix intersection search through NVivo), respondents often referring to the 'need to have support for the initiation of the project' and 'support within the major decision making of the project'.

Although Leadership was at times referred to as Management Support, the phrases simultaneously re- ferred to other sub-constructs of Management Support such as availability of funding, resources, etc. This led us to conclude that Top Management Support is a multi- dimensional construct that should be included in the model, and that Leadership is a sub-construct of Top Management Support that relates to the participation and decision-making power shown by managerial staff on the process modelling project. Thus, Leadership was removed from the model and appropriate sub-constructs were included within the Top Management Support construct to compensate for the removal of Leadership.

Project Management (F3) was the most cited success factor across all three case sites (a total of 84 general citations). Data highlighted its multi-dimensional nature, with different respondents referring to Project Manage- ment sub-constructs such as Scope and Objective defini- tions, Quality Management, Knowledge Management, Time Management and Communication Management. However, there was substantial overlap between Project Management and other constructs of the *a priori* model (such as Team Structure, and Communication). Following detailed analysis of this overlap, and considering those citations that specifically stated the importance of Project Management (a total of 20 specific citations of its importance), Project Management remained in the model. While the *Team Structure (F4)* construct was mentioned within the interview data, there were only a few citations that specifically stated its importance (a total of only two citations across all case sites, and these two citations also overlapped with the project management citations). Furthermore, this construct substantially overlapped with other constructs such as Project Management and Communication. Given weak evidence of its existence, Team Structure was removed from the model. Similar to Team Structure, *User Competence (F5)* had few general citations (19 in total) and specific statements (six in total) that described its low relevance as a success factor for process modelling, thus, was removed from the model.

Modeller Expertise (F6) was consistently cited as an important element of success in process modelling (16 citations specifically stating its criticality for a modelling project). However, Modeller Expertise, overlapped with other constructs, for example, Communication and Getting Information (Information Resources). This suggested possible overlap with the Modeller Expertise sub- constructs that included the 'required skills','knowledge' and 'experience' the modeller ought to have, in order to succeed on a process modelling project. The specific citations on modeller expertise clearly stated its importance. This justified Modeller Expertise as a separate construct, thus it remained in the model and the other overlapping constructs were analysed with care.

User Participation (F7) had consistent supporting citations across all projects and perspectives, a very clear indication of its importance as a success factor. However, the data suggested that respondents were referring to Participation in general and more specifically to the participation of the Process stakeholders. Process stake- holders have a role in the processes being modelled, and may or may not be model users, and hence this construct was re-defined as *Stakeholder Participation*. It was also noted that Participation overlapped to some extent with Communication, and Getting Information (Information Resources) (evident after a matrix intersection search through NVivo). Data coded under each of these were reviewed carefully to remove these potential redundancy issues. However, Participation remained in the re-specified model, due to the relatively strong citations that specifically stated its importance (19 specific citations in total, mostly with strong emphasis on its importance).

While the importance of *Communication (F8)* was specifically mentioned several times (45 general citations and 16 specific citations about its importance), there seemed to be a high level of overlap with the data coded under other constructs, especially Participation and Modeller Expertise. A closer analysis of the Communication construct aided in making the observation that there were two types of communication processes within a modelling project: (a) *Information Sharing*: communication among the modelling team members for sharing information and (b) *Feedback*: communication between the modellers and the users to confirm the correctness of the models. The content coded under 'Feedback' was identical to the intersection between Communication and User Participation. Thus, this segment was identified as a sub-construct of User Participation rather than a separate construct of its own.

Information Sharing was perceived to be an aspect that should be planned for and addressed within a good project management plan. Thus, this was included under Project Management. A matrix differences search con- ducted between Communication and the two re-located sub-constructs of Communication (Feedback and Information Sharing) supported the conclusion that the core aspects of communication are captured under Participation (the 'Feedback' sub-construct) and Project Management (the 'Information Sharing' sub-construct). Hence, there was no need for a separate Communication construct in the re-specified model.

Table 4 Counts of ‘general’ citations of model constructs: by interviewee, within the nine process modelling projects

Success factors															
A priori													*New*		
F1 Top mgmt Support	*F2 Leadership*	*F3 Project mgmt*	*F4 Team structure*	*F5 User competence*	*F6 Modeller expertise*	*F7 User participation*	*F8 Communi-cation*	*F9 Modelling language*	*FI0 Modelling method*	*F11 Modelling tool*	*F12 Complexity*	*F13 Importance*	*F14 Culture*	*F15 Information resources*	*F16 Need*
P1: Work request automation project: Technical Services Group (TSG)															
6	2	2	4	3	2	6	2	2	5	3	4				3
P2: Freight booking system project: Infrastructure Services Group (ISG)															
6	2	2	2	2	4	6	1	0	2	4	2		3		
P3: Train control transition project: across Queensland Rail															
3	2	3	2	3	3	2	2	1	1	2					
3	8	2	4	1	7	7	6	0	3	5					
P4: Rail Supply Chain Optimization (SCOR) Project: supply division															
2	0	4	1	1	2	2	3	2	1	2	1				
4	3	1	0	1	2	1	1	2	0	1			1		
24	17	14	13	11	20	24	15	7	12	17	7	0	4	0	3
P5: Knowledge–economy Project															
7	4	7	1	-	1	2	5	5	1	6	2	2	3	1	
2	2	12	2	2	3	3	2	2	6	5	2	3	2	—	
1	3	5	3	1	5	9	2	4	3	2	3	3	1	—	
4	2	17	7	1	2	6	4	3	4	5	5	—	1	—	
14	11	41	13	4	11	20	13	14	14	18	12	8	7	1	0
P6: IP Telephony Assurance Project															
4	2	7	0	2	2	2	3	2	4	4	2	1	2	9	
P7: Interim Mini-Stats Ordering Project															
7	4	11	1	1	7	2	5	2	2	2	2	2	2	12	
P8: Pay phone Faults Detection Project															
3	2	4	0	0	7	7	4	2	3	6	5	2	1	8	
P9: Supplementary Worker Project															
2	4	7	2	1	7	2	5	0	0	1	0	0	0	6	
16	12	29	3	4	23	13	17	6	9	13	9	5	5	35	0
54	40	84	29	19	54	57	45	27	35	48	28	13	16	36	3

Table 4 Continued

Interviewee	*Success measures*								
	A priori					*New*			
	S1 Modeller satisfaction	*S2 Model quality*	*S3 Model use*	*S4 User satisfaction*	*S5 Process mod-elling impact*	*S6 Usefulness*	*S7 Individual impact*	*S8 Process impact*	*S9 Others*
QUEENSLAND RAIL									
Internal modeler	0	0	1	1	0				
Irternal modelers	0	0	0	1	0				
Internal modeler	0	2	4	0	1				
Project sponsors	0	0	3	0	0				
Irternal modelers	1	1	2	0	1				
Project sponsor	0	0	3	0	4				
OVERALL SITE analysis	1	3	13	2	6				
QUEENSLAND TREASURY									
Eternal modeller 1	1	3	5	2		2	2	1	Achieved objective 3
Externalmodeller 2	0	5	4	1		2	1	0	Achieved objective 2
Internal modeller 3	1	3	4	3		1	5	4	Achieved objective 1
Project sponsor	1	3	2	1		5	0	6	Achieved objectives 3
OVERALL SITE analysis	3	14	15	7		10	8	11	9
TELSTRA QUEENSLAND									
Internal modeller 1	1	2	1	3		1	2	1	met purpose 1
Internal modeller 1	1	2	0	5		3	2	2	met purpose 1
Internal modeller 1	0	0	1	1		1	0	0	
Internal modeller 1	0	0	0	2		0	2	0	
OVERALL SITE analysis	2	4	2	11	0	5	6	3	2
Consolidated Total	6	21	30	20	6	15	14	14	N/A

A new issue (or factor) 'Getting Information' was raised in data gathered within the second and third case sites. We identified this as a success factor because of the relatively high number of citations (a total of 34 general citations and 14 specific citations that stated its impor- tance). After careful analysis of the data gathered within the case study, this construct was re-specified as *Informa- tion Resources (F15)* and defined as 'those resources available to inform the modelling project'. This new construct substantially overlapped with the Participation construct. This can be explained by the fact that Participation, in the context of process modelling initiatives, was important, mainly to gather relevant information to undertake the modelling, and for review- ing the completed models. However, it was made evident from the data that Information Resources emphasized the *state* of information available, while Participation em- phasized the *process* of gathering information. Thus, both constructs remained in the re-specified model.

All three initial modelling-specific constructs, the *Modelling Tool (F11)*, the *Modelling Technique* (a.k.a. Model- ling Language) *(F9)* and the *Modelling Guidelines* (a.k.a. Modelling methodology) *(F10)*, remained in the model. It was interesting to note that although they all had citations to support their relevance and importance in a process modelling project, they all scored lower overall general citations than the project-specific factors Participation, Project Management and Top Management support (see Table 4, last row). This suggests the relative importance of project-specific factors within a process modelling project. Five new success factors were identified across the case studies (see Table 4, columns F12–F16). The most substantial of these, 'Getting Information' (Information Resources), was discussed earlier. Two new constructs were identified from the first case site: *Need (F16)* and *Culture (F14)*. The Need construct captured 'how impor- tant the overall initiative is' (in other words, what motivated the process modelling project), and Culture was 'the organizational readiness to accept and partici- pate in a modelling initiative'. The Need construct was later re-defined with some reference to past literature (e.g., Seddon, 1997), to *Importance (F13)*, which was defined as the criticality of the process modelling project to the organization. This new Importance construct was further justified in the succeeding case studies and was included in the modified model. However, no strong evidence was collected from any of the case studies to justify having Culture as a separate construct in the modified model (only four citations had mentioned its importance). The data suggested that culture would be influential for the 'initiation of a modelling project rather than for the 'success' of the project'. Furthermore, Culture was a reflection on the Leadership and Top Management Support constructs. Thus, it was not included as a separate construct in the modified model. *Complexity (F12)* was another new construct, which was identified from the very first case study. Initially, it was defined as 'the complexity of the processes being modelled as well as how the detailed modelling was to be done'. This construct was further justified in the succeeding case studies and was later re-specified and re- defined as 'the many different features of the processes modelled' (such as the number of inputs, outputs, variants, involved stakeholders of a process, etc.), captur- ing the complexity of the processes being modelled. Based on this analysis, both Complexity and Importance (previously known as 'Need') were included in the re- specified process modelling success model, as moderating variables. They were hypothesized as moderating vari- ables as (a) neither Complexity of the process nor the Importance of the project are things that one can influence or change once the project is approved (whereas all other independent factors of the model are manageable to some extent), and (b) while their existence did not prove to have any direct impact on the dependent variables, they seemed to influence how other success factors such as Top Management Support, Project Management, Modeller Expertise, Modelling Tool and Modelling Technique, etc. related to the dependent variables (evident from a matrix intersection search through NVivo2.0).

Re-specifying the dependent variables: the success measures

The data analysis strategies employed for the success measures were the same as those for the success factors.. However, it is noted that the amount of data coded under the success measurement nodes was relatively less com- pared to that for the success factors. Respondents were often not very familiar with concepts of 'success measure- ment', especially within the context of process modelling. *Modeller Satisfaction (S1)* was the least supported success measure, with relatively fewer general citations. There were citations that specifically denoted its irrelevance as a success measure (three in total – 50% of total general citations). Respondents referred to its potential for being biased, especially when respondents are modellers, and suggested it is unsuitable as a success measure. Thus, it was removed from the modified model.

Both *Model Quality (S2)* and *User Satisfaction (S4)* constructs were supported by the case studies, always scoring a relatively higher number of general citations and specific citations (Model Quality 7, User Satisfaction 13) discussing its importance. Thus, both Model Quality and User Satisfaction were integrated as success measures in the modified model. *Model Use (S3)* received the highest number of general citations (30 in total). However, very few respondents supported its relevance as a success measure and they commonly agreed on the difficulty in effectively measuring the 'level of model use', thus denoting that it was not a suitable measure for process modelling success. Furthermore, this construct substantially overlapped with the new Usefulness, In- dividual Impacts and Process Impacts constructs (evident from a matrix intersection search). Thus, Use was removed from the modified model.

Earlier case study analysis raised concerns about the 'Use' construct (i.e., in terms of difficulty of measurement and irrelevance to the context of process modelling). Similar concerns are raised in the IS success literature. Seddon propose usefulness in place of use (Seddon, 1997). Thus, *Usefulness (S6)* was integrated into the modified *a priori* model for the latter case studies (after the Queens- land Rail project analysis was completed). While there were a substantial number of citations on usefulness (15 in total from just five investigated process modelling projects), it also showed substantial overlap with the impacts constructs, when an intersection search was conducted through NVivo. Thus, it was removed from the modified model.

The *a priori Process Modelling Impacts (S5)* construct was decomposed into two separate constructs after the data analysis of the first case site. The decomposition consisted of *Individual Impacts (S7)* (which refers to how process modelling has influenced the Process stake- holders; those who have a role in the processes being modelled) and *Process Impacts (S8)* (which refers to the overall effect of process modelling on the processes modelled). This was initially identified within the analysis of Queensland Treasury. This decomposition was further tested within the Telstra projects and was supported (most impacts related citations were around the two main themes of impacts to individuals and impacts to the processes being modelled). Thus, the single *a priori* 'Impacts' construct was replaced by the two decomposed constructs of 'Individual Impacts' and 'Process Impacts' in the modified model.

Other potentially useful success measures were care- fully explored from the data collected on the case studies. The degree to which the modelling activities fulfilled their initial objectives and met intended goals was raised as an important measure at several points in the case studies. Citations often referred to the process modelling project's ability to maximize invested resources in relation to the obtained outcomes. While this was considered important, it did not 'fit' within any of the existing measurement constructs. Thus, a new measurement construct *Process Efficiency* was later added to cater for this, and was defined as 'the process modelling project's ability to maximize the obtained outcomes in relation to the invested resources'.

The overall re-specified process modelling success model

Figure 2 summarizes the re-specified success model derived from the multiple case studies. In summary, the analysis of the success factors resulted in: (a) Leadership, Team Structure, User Competence, Communication and Culture being removed from the model due to overlap with other more holistic (deemed so, by the support from the literature and specific statements from case data) constructs and/or due to lack of evidence to support their existence as a separate success factor; (b) a new success factor, 'Information Resources' (Getting Information); (c) two new moderating variables – Complexity and Im portance, and (d) User Participation was re-defined as Stakeholder Participation.

The analysis of the success measures resulted in the following insights: (a) two levels of potential process modelling impacts were identified. Process modelling impacts at the individual Process stakeholder level (Individual Impacts) and process modelling impacts at the overall process level; (b) Modeller Satisfaction was removed from the model due to its potential for bias and its perceived lack of relevance as a success measure; (c) The Model Use and Usefulness constructs were removed from the model because of perceived overlap with the other measurement constructs; and (d) a new success measure; Project Efficiency was identified and included in the model.

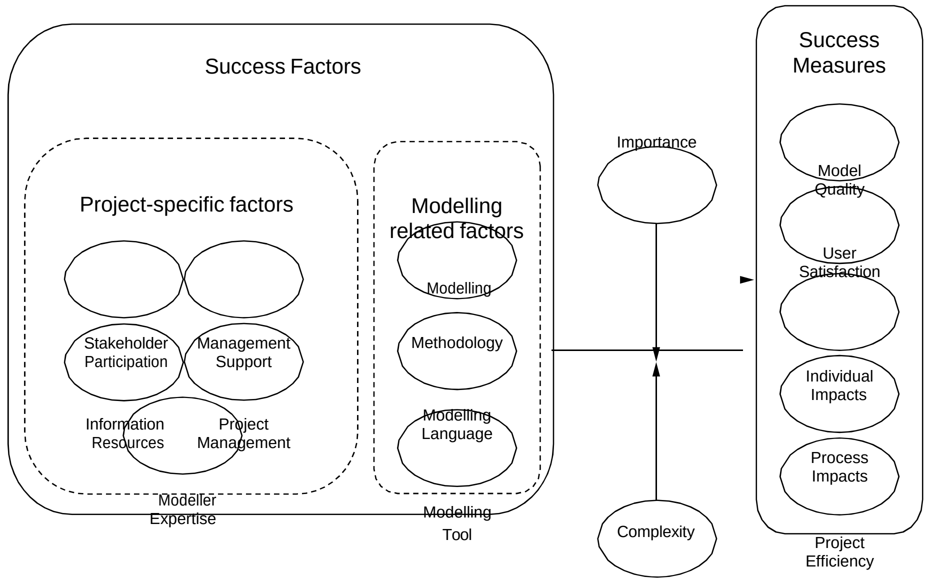

Figure 2 Re-specified process modelling success

Study contributions, limitations and outlook

This paper reported on the extent to which multiple case studies contributed to the design of a process modelling success model. The identified success factors (both modelling specific and generic factors) can be usefully addressed by practitioners to plan and conduct a model- ling project. The reported process modelling success model also provides clear guidance on how to practically measure the effectiveness and efficiency of a modelling project. It is anticipated that the model reported in this study can also be readily adapted and tested within other modelling domains.

No theory exists in relation to the study questions. Thus, relying on extant theory was not possible. The study draws heavily on referent and analogous domains to establish the initial set of candidate success factors and measures. It is recognized that these 'other domains' may have been overly influential (due to differences in context). Case studies of process modelling projects were conducted to empirically modify and further 'build' the model. The case study data and approach did not allow for rigorous testing of the relative influence of the success factors on the success measures – an inherent weakness of most success factor studies (Nandhakumar, 1996). The study will next be extended to address these limitations. The model will be operationalized for the purpose of a quantitative survey and subsequent statistical testing of model completeness and validity. These data will also facilitate testing the predictive power of the success factor.

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